NORTHEASTERN FOREST EXPERIMENT STATION

Semiannual Report
Watershed Management Research

October 1, 1966 - March 31, 1967

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PROJECT 1601 - WATER YIELD IMPROVEMENT

Watershed #2 Treatment

First-year results are now in for our completely clearcut watershed. Although the results are on a calendar year basis and probably do not reflect the best water year relationships (May 16 to May 15 was found to have the highest correlation of precipitation to streamflow), nevertheless remarkable increases in water yield were achieved.

Prior to treatment, guesstimates of water yield increase by various experts ranged from 4 to 10 inches. We got 13½ inches increase! (See Table 1). This is 1½ " more than the estimated greatest increase reported from experiments in West Virginia and only 2½" less than Coweeta's famous watershed #17. Rainfall averages about 56 inches at Fernow Experimental Forest, 80 inches at Coweeta, and 48 inches at Hubbard Brook. Also, our watershed is a southeast-facing slope of 33%.

Several interesting facts are evident from these results:

1. Snowmelt runoff was advanced in time--the largest portion left the watershed in March whereas on the control watershed it did not melt until April.

2. The greatest increase (13 inches) occurred during the growing season (May 16-October 15).

3. Streamflow in the traditionally low flow period in the summer (August 1-October 15) was increased from a predicted 2.2 inches to 10.7 inches.

4. Substantial streamflow increases in August can be credited to more than double the normal rainfall; however, it should be stressed that in spite of the excess rainfall, streamflow in watershed #3 (the control) remained at the usual low summer level, whereas flow in the clearcut watershed was 6 times the control.

Our reasons for the high efficiency in our yields are:

1. Impermeable bedrock and thus negligible deep-seepage losses.

2. Virtual elimination of transpiring vegetation in the watershed during the growing season by application of an herbicide (Bromacil). Annual P-RO has been reduced from about 20 to about 6½ inches.

Table 1.

FIRST YEAR STREAMFLOW INCREASES FROM CLEARCUTTING

	Precipitation (Area inches)			Streamflow (Area inches)				
	#2 Clearcut Watershed 39A	#3 Control Watershed 105A	8-yr. Avg.	#2 Actual	#3 Actual	#2 Predicted based on #3	Diff. #2 Pred. - #3	Accumulated Difference
Jan	2.5	2.5	4.2	1.6	1.5	1.7	- .1	- .1
Feb	2.3	2.4	3.7	1.2	.9	1.0	.2	.1
Mar	4.5	4.5	3.1	7.6	4.6	5.5	2.1	2.2
Apr	2.6	2.6	4.3	6.1	7.1	7.2	-1.1	1.1
May	3.5	3.6	3.7	3.9	3.9	4.3	- .4	.7
Jun	4.2	4.2	3.4	3.3	1.3	1.4	1.9	2.6
Jul	3.9	3.8	7.5	3.1	.2	.2	2.9	5.5
Aug	7.7	7.6	3.2	5.8	.8	1.2	4.6	10.1
Sep	4.6	4.6	3.4	3.8	.8	1.0	2.8	12.9
Oct	3.2	3.2	5.5	2.9	1.8	2.1	.8	13.7
Nov	5.3	5.3	5.3	5.2	4.7	5.2	0	13.7
Dec	3.8	3.9	4.1	2.2	2.1	2.4	- .2	13.5
	48.1	48.2	48.3	46.7	29.7	33.2		13.5

Forest Meteorology

Much of the past six months has been spent in completing the radiation study reported in the last semiannual report. Results were obtained on two summer days, one early fall day (full color), one late fall day (leaves off, no snow) and one winter day (snow on ground). A manuscript has been started through the publication mill. Statistical analysis showed significant differences between some of the hardwood sites, but they were small, covering a range of about 0.03 in albedo, 3C in surface temperature and 0.03 ly/min in net radiation regardless of season. Variation over the adjacent pine, juniper, ledge and field sites was about three times as great in all three variables, except in winter.

A second major project has been literature review on micrometeorological methods of obtaining evapotranspiration. This has led to a review article to be published and will be used in an upcoming study plan on the application of these methods to forests.

Wind and temperature profiles were obtained during one week in October at the Pack Forest in New York. This is a joint study with Ray Leonard's Project 1604. Much had been learned from our experiences in 1965 and the data are useful but not excellent. Some of the problem is undoubtedly due to heterogeneity of the site itself but we cannot avoid this in practical forest meteorology. The data indicate a roughness length of about 1-2 m and a zero plane displacement of 10-12 m (greatest height of closed canopy) but the results are yet to be refined with diabatic profile corrections.

--R. S. Pierce
C. A. Federer

PROJECT 1602 - FLOODS AND WATER YIELD

Half-cut Watersheds

The upper half of 60-acre Watershed 7 was cut in 1963-64 and kept nearly bare of vegetation since by use of herbicides. Starting last fall, Lower Seven is being given the same treatment. All woody stems were sprayed with 2,4,5-T in oil; next sawlogs were harvested. A pulpwood operation is now under way; this will be followed by mistblower application of herbicides after growth starts this spring.

The relatively slight effect of this severe treatment upon storm flows continues to be surprising. A preliminary analysis was made of 29 storm periods after treatment of Upper 7; storm peaks were appreciably increased in 2 of the 29. Such increase was evident only when a particularly dry period was followed immediately by a particularly heavy rain. This attests to the influence of antecedent soil moisture.

Post-snowfall Weather Sequences

Most flood flows in the vicinity of the Fernow Experimental Forest are caused by the frequently occurring combination of snowmelt and rainfall. One proposed method for alleviating these flood flows is to desynchronize snowmelt runoff by varying the land use pattern between open land and forest or by varying forest density. For this idea to work, the length of time between snowfall and complete snowmelt must be sufficiently long and the necessary weather sequences must occur. We are currently beginning a study of post-snowfall weather sequences using 70 years of record from nearby Elkins, W. Va. From this study we hope to be able to assign probabilities to the length of time between snowfall and melt and to the occurrence of variables (such as percent cloud cover, degree days, wind movement, etc. for post-snowfall periods) which affect the speed of melt.

The Effect of Clearcutting and Herbicide Treatment on the Forest Floor

A study with this title has just been started. We plan to measure deterioration in five years after treatment by measuring loss-on-ignition from the L and F plus H layers and from the 0- to 3- and 3- to 6-inch depths of the mineral soil. We once tried to study this kind of thing based on linear depth measurements with poor results; we hope this weight approach will do better.

A Switch in Count Saves Time

We are quite happy with the results of an idea borrowed from the July 1966 ARS Technical Information Exchange memo. By adding an inexpensive and simple switching and counting mechanism to our solar radiation integrator, we are now able to obtain solar radiation on a solar day basis without coming back to the office after sundown or prior to sunup. More information can be obtained from us or from the developers, James L. Wright and Marvin E. Jensen at Twin Falls, Idaho.

Weather Records

Official weather records have been kept at Parsons since 1899. In January we began to think that our climate was getting drier: precipitation was only 1.06 inches, the lowest January ever recorded here. March has convinced us that our climate is getting wetter; precipitation of 9.53 inches was the highest March ever recorded.

--K.G. Reinhart
J.W. Hornbeck
C.A. Troendle

PROJECT 1603 - WATERSHED CORRELATION AND SYNTHESIS

Municipal Watersheds

Results of the Newark watershed treatments are beginning to show up. On Watershed No. 3 all trees greater than one-inch in basal diameter were injected with "Tordon" or "Weedone" in the fall of 1965. The laurel undergrowth on the watershed was sprayed using a portable mist-blower. The herbiciding resulted in a 70 percent kill by the summer of 1966. This treatment provided an increase of 5.15 inches of water during the 1966 May-October growing season. Total runoff during this period was 8.17 inches. The increase was significant at the .001 probability level. An areal application of herbicides is planned for the spring in an attempt to reduce the live woody vegetation to as close to zero as possible.

Injecting herbicides into trees along the streamside zone (21 feet each side of the stream) of Watershed No. 1 deadened only about half of the vegetation; even though many of the trees were injected more than once. The larger red maples, yellow birch, tulip poplar, black birch, and beech were the hardest to kill, in about that order. The oaks seemed to show effects almost immediately. The 50 percent kill had no significant effects on streamflow. This winter all trees in the streamside zone were cut in order to evaluate this limited treatment on water yield.

Correlation Studies

Howard Lull spent the last six months alternatively assembling climatic data for a long-term streamflow-trend study, and drafting and redrafting co-authored papers for Water for Peace, and a Station Paper on white pine humus. Recently, he has been assembling literature and ideas for his part of a study with Ken Reinhart to re-evaluate forest-floods relationship in the Northeast. In his literature search Ken came up with a quote from Hoover (Herbert, that is): "The floods of the Mississippi...cannot wait for trees to grow up even if they were a contributory remedy. But in any event, I am for trees." They also found that the concept of a mixture of open land and conifers as the best land use for reducing snow-melt floods in the Allegheny Plateau, as expressed by Satterlund-Eschner in 1965 (Water Resources Research 1: 397-405) and by Ayers in 1959, was also suggested from stream gaging studies of the Flood Control Survey in a 1941 unpublished report.

Two other items worth noting. The National Weather Records Center has been very helpful in sending us climatic records for our trend study on 23 watersheds. We have compiled over 1,000 years each of monthly precipitation and mean temperature data from records sent to us without charge from Asheville, N.C. The other item concerns our white pine humus data from 65 stands in Massachusetts. Total depths and weights of the L, F,

and H layers were found to be not closely related to age of stands, site index, basal area, elevation, and soil drainage class, singly or in combinations. The highest multiple correlation coefficient accounted for 35 percent of the variations. We hypothesize a humus-eater that consumes just enough humus to keep accumulations out of phase with our independent variables.

--Ed Corbett
Howard Lull

PROJECT 1604 - STREAM REGIMEN AND WATER YIELDS

The cooperative watershed management project at the College of Forestry has been strengthened by the addition of a forest meterorologist and a soil physicist to the college staff. At the present time, the project is involved with 5 Master's and two Ph.D. candidates, as well as 7 faculty members, on investigations in water regimen or environment.

Solar Radiation Relationships

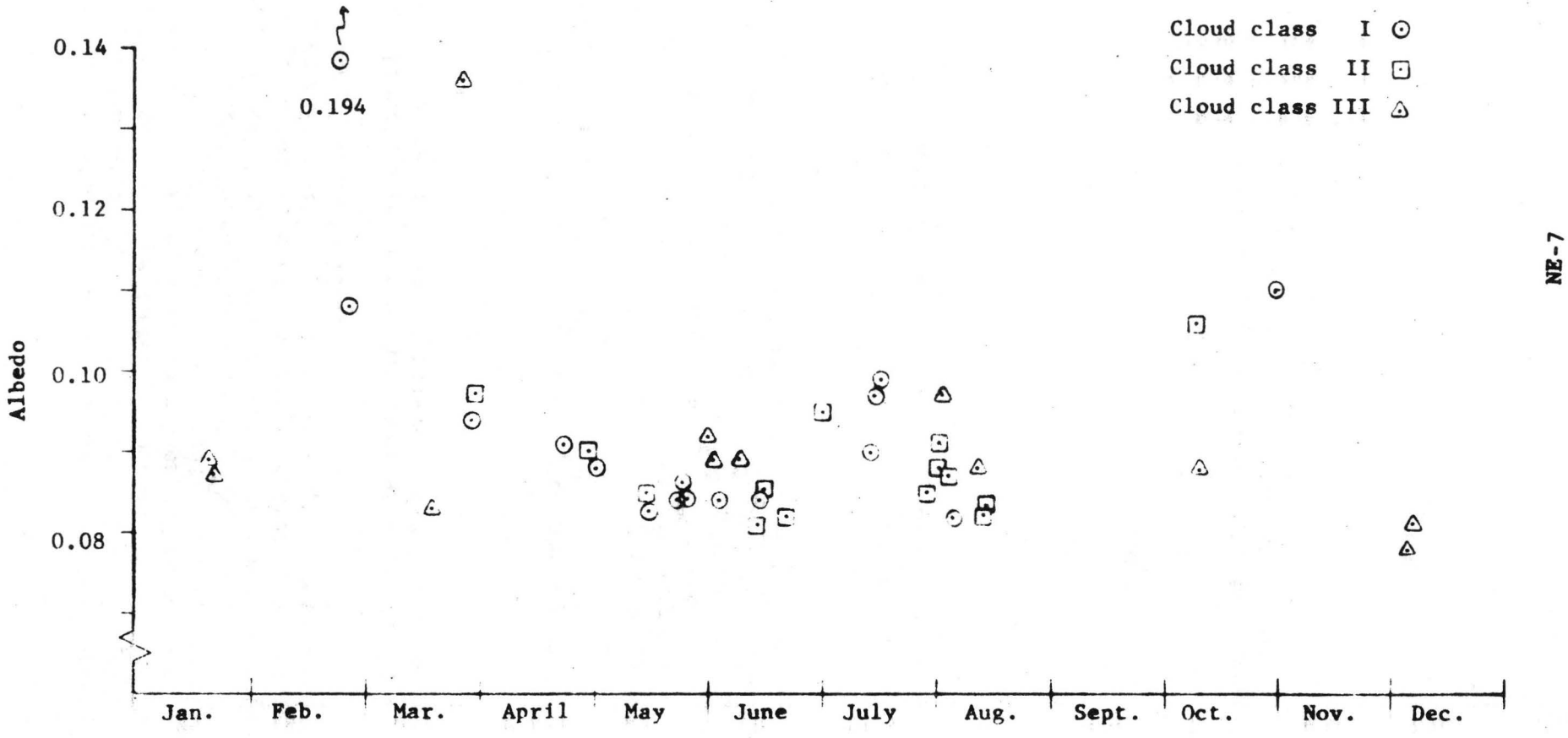
The aerial tramway system used to investigate time and space variation of reflected short wave radiation above a red pine stand at Warrensburg, N.Y. has been in operation for over a year. Approximately 40,000 measurements have been taken and processed during this period. Five different 100-foot tramways have been in operation. Instruments are moved along the cable tramways at varying speeds by means of electric winches; instrument output is recorded on a recording complex at the base of one of the towers.

An analytical model has been developed using linear systems analysis techniques to characterize instrument response in time and space for the various tramways.

The magnitude of albedo changes during various portions of the year can be seen in the plotting below. This is a plotting at approximately solar noon for clear skies (I), cloudy sky (II), and complete overcast conditions (III). Note in the figure that the lowest and highest albedo apparently occurred during the winter months.

Spatial variation in albedo along the 100 foot tramway expressed as coefficient of variation ranged from 8.4 percent down to 1.9 percent.

Radiation investigations at this project have been extended by the construction of a new tramway system in a 65-foot hardwood stand. Measurements are to include time and space variation prior to leaf emergence this spring and continue through the leaf period during the summer as well as into the snow season next winter. Data from this system will be presented in the next semi-annual report.


Cloud class I
Cloud class II
Cloud class III
0.194
0.14
0.12
0.10
0.08
Albedo
Jan.
Feb.
Mar.
April
May
June
July
Aug.
Sept.
Oct.
Nov.
Dec.
NE-7

Six study areas, four at or above timberline and two below, have been chosen for vegetational-ecological analysis in 1967. Selected standard erosion control techniques will be tested in these plots following the analysis. In addition, permanent plots have been selected along two new trails established in 1966; one of these trails, located by the Conservation Department with full consideration of both esthetic and ecological values, contrasts sharply with the second, put in on private land, without regard to ecological consequences. Additional test plots may be placed on one or more of the remaining sixteen peaks over 4,000 feet scheduled for reconnaissance in 1967.

Parallel studies will be initiated in the White Mountains in 1967 by a Ph.D. student from the Department of Forest Botany, State College of Forestry, Syracuse.

Snow Interception

The continuing investigation of snow interception by conifers produced more interesting information this past quarter.

As previously reported, three small conifer trees, 5 to 6 feet high and mounted on platform scales are being monitered for weight changes during and following periods of snowfall. The table below presents data from one tree during the period following a snowstorm in March 1967. The storm stopped at around 0830 hours and intercepted snow had left the tree crown by about 1400 hours. Approximately 4 inches of snow was on the ground at the end of the storm.

Time	Weight (pounds)	Water equivalent on projected crown area (mm depth)	Solar radiation during interval (ly.)
0840	208.00	4.77	
1045	201.50	1.97	52
1155	198.00	1.06	47
1345	193.50	1.36	110
1630	192.25	0.38	86

The fairly constant rate of change in weight is accompanied by a steadily increasing amount of measured solar radiation. Air temperature remained between 16°F and 18°F during the daylight hours.

Trail erosion in the Adirondack Mountains

This study is an investigation of the increasing impact of recreationists upon forest and watershed values in the high-country of the Adirondack Mountains where increasing traffic along mountain trails has induced severe erosion on the steeper slopes and in places has led to drastic site deterioration. The damage being studied is most pronounced in two physiographic situations.

1. The alpine zone at the summits where the tundra meadow is in delicate, precarious balance with extreme environmental conditions, and consequently, has limited carrying capacity for trespass by hikers and climbers.

2. The upper reaches of the spruce-fir belt near timberline where thin soils on impervious bedrock are subject to washout wherever trails are established.

The specific objective of the study is to provide the basic ecological information and understanding necessary for multiple-use management decisions involving the unusual vegetational types existing on and near mountain summits in the northeastern United States.

The reconnaissance and inventory phase of the study was initiated in July-August 1966. Thirty peaks were visted; twenty of these are approached by regular trails maintained either by the New York State Conservation Department or private organizations, and ten peaks are classified as "trailess" though in fact unmarked paths are becoming more evident each year as interior camping and hiking becomes more popular with the recreating public. On each peak observations were made, photographs taken, and records prepared reporting the severity of the damage. In contrast to the floristic uniformity of the Picea-Abies association that generally clothes all mountain slopes across the Adirondack high-country, trail erosion and site deterioration varied markedly from summit to summit. Ecological integrity of site depends upon six primary factors:

1. History of fire, especially from regional fires in 1903 and 1908;

2. Extent of logging in each watershed prior to inclusion of the area in the Forest Preserve;

3. Local severity of blowdown from the land storm of November 25, 1950, which leveled or disturbed thousands of acres of forests in the region;

4. Accessibility of the particular peak to the recreation public;

5. Length of time the trail has been in existence;

6. Ecological variables of site, especially the three major factors of elevation, aspect, and slope.

PROJECT 1605 - FOREST RESTORATION OF STRIP MINED LANDS

Willie Curtis transferred to Berea from LaCrosse, Wisconsin during the Christmas holiday season to fill our hydrologist position. This position was vacant since August when Dave Striffler left. He is an important addition to our staff, and we have now filled all scientific staff positions at Berea.

The Kingston (Pa.) Unit has now become attached to our 1605 project. They have been conducting research on revegetation of coal mine spoils in the Bituminous and Anthracite Regions in Pennsylvania. Dr. Miro Czapowskyj, Soil Scientist, has been heading up research on hard coal spoils. Grant Davis conducted research in the Bituminous Region, but this position has been open since July when he transferred to Berea as project leader. Ed Sowa is the research technician, but he also has the administrative duties.

--Grant Davis

Hydrology

Our study of the effects of strip mining on watershed values is shaping up. The study is being strengthened by extending the study of Leatherwood to include Bear Branch Watershed. Bear Branch has been gaged by the USGS since December 1954. Drainage areas are approximately the same: 2.39 sq. mi. for Leatherwood and 2.21 sq. mi. in Bear Branch. Plans are underway to gage the flow of six small tributaries within these two watersheds. These sub-drainages range from 170 to 400 acres.

Stripping will begin by late summer on at least one of these tributaries and we hope to follow the progression of mining around the perimeter of the main watershed. In this process some sub-drainages will be "untreated" while others are mined.

Objectives of the study are to evaluate the influence of contour strip mining on water quality (chemical changes and turbidity) and streamflow (total, storm peaks, base flows). The study might well be carried throughout the mining process and until revegetation of the disturbed area is completed.

Small watersheds are being located for the purpose of testing the effect of small check dams on water quality. Deposition of soil and rock material will be measured periodically and especially after larger storms. Suspended matter from these watersheds will be compared with that of watersheds with no check dams. All watersheds will be mined by the stripping method.

We plan to measure flow from these small watersheds through broad-crested weirs with 3:1 side slopes. Specifications are being drawn up for constructing forms for pre-casting various blocks to be used in these weirs. More will be said about this in the next issue. In the meantime we welcome any comments and criticisms.

--Willie R. Curtis

Revegetation: Trees and Shrubs

Previous years' efforts are beginning to pay dividends. And as we sit back and reflect on what has been done we note accomplishments as well as perplexing frustrations.

One of the problems plaguing revegetation administrators has been practical and reliable methods for assessing the plantability of large acreages of spoil. Present methods incorporate field sampling with personal experience. On some sites this is adequate, but on other areas costly errors have been made due to the heterogeneity of the material. Since a plant is the most reliable evaluator of all of the complex chemical reactions present in these spoils, we are attempting to use seeded herbaceous indicator plants for plantability evaluations. Last spring in cooperation with the Tennessee Valley Authority we seeded nine herbaceous mixtures which included many of the more acid tolerant grasses and legumes. Four hardwood species and three conifers were overplanted the same year. Examinations and analysis in late summer showed a strong correlation between herbaceous plant establishment and tree survival for five of the indicator mixtures: Kobe with Korea lespedeza; Balbo rye; perennial ryegrass with tall fescue; weeping lovegrass; and birdsfoot trefoil with orchard grass. With this encouragement we have expanded our trials this year by testing eight more herbaceous mixtures on small plots and seeding 175 acres with a mixture of three species judged superior in last year's trials. The latter was done to demonstrate the practical applications of our methods. Our proposal is to seed in the spring, then make evaluations of plantability by assessing the percentage of the area with an acceptable ground cover in the late summer. If the area is judged plantable by some arbitrary standards, then it would be planted the following spring. Planting could be done either over the entire area or only in patches where the indicator mixture was established.

If we can develop techniques for evaluation of plantability with seeded indicator plants the methods could have wide application on fresh spoil and on older spoils where either no attempt was made to revegetate them or they were considered too toxic to plant.

Exploratory studies testing methods for applying and evaluating fertilizer, liming, and mulching treatments on extremely acid (pH 3.5 to 4.0) spoils have been encouraging for some tree species. Black locust has responded well to phosphate fertilization under these conditions during the first growing season after planting. Other species which have responded but to a lesser degree are sycamore, red oak, and sweet gum. European alder and Virginia pine response to these treatments varied.

In our trials this year we will investigate the effects of various types of phosphate fertilizers on tree or shrub growth. This is our initial approach because there is evidence that fertilizers with an acid reac-

tion may actually reduce survival and growth of some tree species on these acid sites. Later we expect to evaluate fertilizer rates on spoils with varying levels of inherent plant -available P_2O_5. We believe we have selected a standard test for available phosphate that correlated well with rates of fertilization for herbaceous species in greenhouse trials.

--William T. Plass

PROJECT 1606 - MANAGEMENT OF STORM RUNOFF

This half-year was marked by the start of one new study and the wrap-up of several others, with the result that we have little to no new information to report this time.

In October, Aubertin started a comprehensive search of the literature into past and present research on forest tree roots, their development, growth and decomposition, and the overall effect of this on soil physical and hydrologic properties. We have known for some time that the interconnected mass of voids and root channels in the forest soil profile was an important avenue of water flow and we have decided to learn more of roots, root channels, and their effects on the overall permeability of the soil profile.

This has turned out to be a tiresome, tedious task, for many of the promising titles are foreign and require translation--and, of course, some of the intriguing titles lead to papers that have little or no value to our purpose. But, we do hope the overall effort will result in a very complete bibliography on forest tree roots, a good knowledge of where and how we should emphasize our subsoil research, and perhaps one or several complete papers summarizing the results of this review.

During the same period we spent most of our time attempting to calibrate a small HS-type flume used for measuring minute to medium volumes of seepage from a hillside, devising a plot technique for measuring subsurface stormflow from "unit strips" of a watershed, and in preparing a paper for presentation at a Flood Symposium in Leningrad.

In April Aubertin begins an exploratory study into the use of transects for studying measurable roots, root channels, and voids in a block of forest soil. If productive and feasible, this study will be enlarged and tied into the laboratory techniques being used at Ohio State University.

--R. Z. Whipkey

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Watershed Aspects of Stabilization and Restoration of Strip-mined Areas. Robert F. May and W. David Striffler. In International Symposium on Forest Hydrology Proc.: 663-671, illus. Pergamon Press, Oxford, England. 1967.

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Summary of Discussion on New Instruments. Irvin C. Reigner. In International Symposium on Forest Hydrology Proc. : 807-808. Pergamon Press, Oxford, England. 1967.

Watershed Calibration Methods. Kenneth G. Reinhart. In International Symposium on Forest Hydrology Proc.: 715-723, illus. Pergamon Press, Oxford, England. 1967.

Theory and Mechanics of Subsurface Storm Flow. Ronald Z. Whipkey. In International Symposium on Forest Hydrology Proc.: 255-260. Pergamon Press, Oxford, England. 1967.

Manuscripts submitted:

Fertility Requirements of Fescue, Weeping Lovegrass, and Lespedeza on Strip Mine Spoils. William A. Berg and Willis G. Vogel.

Hydrology of Contour Strip Mines in the Appalachian Region of the United States. Grant Davis.

Clearcutting and the Erosion Hazard. James W. Hornbeck

Protecting Water Quality During and Following Clearcutting. James W. Hornbeck

Important Watershed Characteristics Affecting Water Yield, Flood Peaks, and Erosion and Sedimentation, and the Basic Data Needed for Predictions. Howard W. Lull and Henry W. Anderson.

Opportunities for Pulpwood Management on Strip-Mines in the South. William T. Plass.

Land Distrubances from Strip-Mining in Eastern Kentucky. William T. Plass.

1. Upper Cumberland Coals Reserve District
2. Princess Coal Reserve District
3. Licking River Coal Reserve District
4. Big Sandy Coal Reserve District
5. Hazard Coal Reserve District
6. Southwestern Coal Reserve District

An Evaluation of Streamflow Timing from Small Watersheds in the Northeastern United States. William E. Sopper and Howard W. Lull.

Evaluating Grasses and Legumes for Cover on Acid Strip Mine Spoil. W. G. Vogel and W. A. Berg.

Northeastern Forest Experiment Station

ADDENDUM TO

SEMIANNUAL REPORT
(October 1 to March 31, 1967)

Recently through an exchange of the attached correspondence, we had the opportunity to bring together some ideas on the use of ADR and computers in watershed research. This correspondence was so interesting and helpful to us, that we decided to share it with the other participants of the WMR semiannual report.

Attachments

Dept. of Forestry
and
Rural Development

CANADA
Forestry Branch
132 - 9th Avenue S.W.
Calgary, Alberta

COPY

March 21, 1967

The Director
Northeastern Forest Experiment Station
Forest Service
U.S. Department of Agriculture
Upper Darby, Pennsylvania

Dear Sir:

Collection and compilation of watershed research data

From its inception in December, 1959, the East Slopes (Alberta) Watershed Research Program has grown steadily. At present we have three watersheds, two of them already instrumented intensively for surface water, groundwater and meteorological data while the instrumentation of the third basin is just starting.

A question has recently arisen whether it would be desirable to employ the modern electronic techniques of data gathering, compiling and publication. A similar problem seems to have confronted the Northeastern and the Southeastern Forest Experiment Stations as obvious from the Proceedings of the Watershed Management Research Conference held at Laconia N.H. on June 12-14, 1962. As some years have already elapsed since the recommendations made at the said conference, the present letter is intended to ascertain the current views of your experiment station on the extent to which recourse should be made to the modern data collecting and processing facilities in preference to the methods traditionally applied so far in watershed research.

The considerations involved, and the questions arising therefrom, can be briefly summarized as follows:

1. Field data collection: Is it justifiable to use automatic digital recorders (e.g. Fischer-Porter ADR) for collecting the field data? If so, should such recorders replace the existing instrumentation or only be considered for new instrumentation where needed? Does the additional investment balance the automatic data recording and processing benefits in the long run?

2. Data compilation: Are the present methods of compiling data from streamflow and meteorological charts adequate or should these be replaced with those using modern equipment like chart scanners and electronic computers?

3. Quality control, summaries and publication: Should the computer techniques be preferred over the non-computer techniques that are presently being used?

4. Biometric and other analyses: Is it worthwhile to put all the previously compiled data on punched cards (or magnetic tape) for use in future analyses?

Obviously, these and other such questions are closely interrelated. So far we have been compiling our data without using the modern electronic devices and there is no backlog of untabulated charts.

Although most of the questions posed above have ultimately to be decided by us, I would like to invite your considered opinion on this matter especially as a follow-up of the conference mentioned above. It would also be appreciated if you would let me know what steps have so far been actually taken by the Northeastern and Southeastern Forest Experiment Stations (and the Coweeta Hydrologic Laboratory) towards computerization of meteorological, streamflow and groundwater data.

Yours very truly,

/s/ Teja Singh
Teja Singh
Research Scientist

COPY

Northeastern Forest Experiment Station
6816 Market Street, Upper Darby, Pa.

March 30, 1967

Mr. Teja Singh
Research Scientist
Forestry Branch
132 - 9th Avenue SW
Calgary, Alberta

Dear Mr. Singh:

Whether you should computerize your hydrologic network and data depends, I presume, on whether or not it would yield sufficient benefits. I can't answer that for you, nor can anyone else; nor, to my knowledge, has any watershed research project satisfactorily answered this question before embarking on computerization. Perhaps it's a question that can only be answered by first programming and then deciding what to do with the data. That doesn't make much sense, but so far computers, for the purpose in question, have been embraced more with faith than logic.

I have noted no great outpouring of research results from projects that have computerized. I do know that, up to now at least, the programming and debugging has been an expensive, tedious, and time-consuming process.

The significant research results in the East in the past decade have not come from ADR-computers but from pencil, paper, and a few ideas. I include here Coweeta's soil-block studies, their quick-flow-delayed-flow concept, their recent and striking results from watershed 13 and their grass watershed, the series of papers on the Fernow Five, and Hubbard Brook's note on sources of winter streamflow.

Computers have been used to good purpose to analyze stockpiles of hydrologic data. Fernow employed them to develop flow-duration curves, and to predict daily potential ET for several years of record. Coweeta used them for their quick-flow analysis. We have used them at this office to analyze 2,300 years of daily streamflow records from stations in the Northeast. For this kind of studies, there is, of course, no choice. Computers must be used.

But whether you want to go into ADR and all the rest to produce neatly printed pages of streamflow data is, as you say, your decision. The necessary labor is a great substitute for thought. But, it may require unthinking use of this equipment to reach the next level, namely, "we got 'em, now how do we use 'em?"

As far as this Station goes, I will ask Ken Reinhart and Bob Pierce to

tell you their experiences, and I will send a copy of your letter to Jim Douglass and John Hewlett who have ideas of their own. Your questions are interesting and well-put. I am sure that the answers I am soliciting for you will be revealing and more useful than this one.

Sincerely yours,

Howard W. Lull
Project Leader

cc: K. G. Reinhart, Parsons, W. Va.
R. S. Pierce, Durham, N.H.
J. E. Douglass, Franklin, N. C.
J. Hewlett, Athens, Ga.

COPY

Northeastern Forest Experiment Station
Parsons, West Virginia

April 11, 1967

Mr. Teja Singh
Research Scientist
Forestry Branch
132 - 9th Avenue SW
Calgary, Alberta

Dear Mr. Singh:

I think Howard Lull has done a pretty good job of replying to your letter of March 21; I doubt that I can add very much to it.

I must admit that I have been one of those slow to adopt the newer methods. There have been several reasons, besides a built-in-conservative approach. For one thing, we had a set-up that was working quite well as it was. Also, we are at an out-of -the-way location and access to distant computers has been unwieldy, to say the least. In spite of all this, I feel that we will all sooner or later be handling our streamflow and similar data on the computer. The question is how much, how soon and in what manner.

I still feel that we can do a pretty good job with hand methods to get daily totals of streamflow. However, I'm afraid we aren't satisfied with daily totals. I was much impressed with the Hewlett-Hibbert analysis of quick flow. We have applied this to some of our data by hand methods. We now contemplate putting about 100 years of gaging station records onto cards or tape so that, among other things, we can make quick-flow analyses. We hope to be able to take the necessary data from our tabulations (tabulations of individual flow intervals, not daily totals) rather than the more expensive approach of going back to the charts.

So far, we have not seen fit to replace FW-1 and A-35 recorders with ADR's. Until recently, the problem of translating the tapes seemed almost insurmountable. This question of difficulty of getting the tapes translated might control your decision, too. I believe that if we were expanding our operation and instrumenting a number of new watersheds, we would probably go to ADR's.

In all of this, there is probably no good substitute for the difficult task of sitting down beforehand and thinking out what use will be made

of the data and what analyses will be made. The closer these decisions are to actual operations later, the more efficient the whole thing will will work.

I trust you will get some more specific advice from those who have actually used the computers more than I have.

Sincerely yours,

K. G. Reinhart
Project Leader

COPY

Northeastern Forest Experiment Station
Durham, New Hampshire

April 13, 1967

Mr. Teja Singh
Research Scientist
Forestry Branch
132 - 9th Avenue SW
Calgary, Alberta

Dear Mr. Singh:

Howard Lull suggested that I comment on the remarks in the correspondence between you regarding the validity of gearing your hydrologic information for automatic data processing.

Dr. Lull has raised some legitimate questions about organizations throwing their data to the machines. If one is not careful, he can succumb to the notion that once his data is computerized, he won't need to think--the computer will produce the results ready made. It is also true that considerable time can be spent in developing programs and debugging them.

Last year we were anxious to keep up with the streamflow data from our first treated watershed. Although we had developed a computer program for processing this data, we could not use it at the time (because of circumstances too lengthy to discuss here) and so relied on the simple manual point-picking method, selecting about one point per day and several for storm periods. At the end of the year when we got our ADP program rolling, we found the simple point-picking method was only 5 percent off. Now if this type of data is sufficient and an error of this amount is acceptable, it is senseless to use a computer.

On the other hand, this data is inflexible. Our experience over the years has indicated that invariably changes are desired in reworking the data. For example, we discovered the areas of two watersheds were not correct and thus the volume rate of water/unit area (csm) had to be redone. We also revised our rating tables (stage height-discharge relationships) based on refined measurements at a later date. These also required revamping the streamflow data. You can see that if revisions in the data are necessary, the cost and time involved in recomputing past records by desk calculator would be prohibitive. If your data is on cards, the computer can redo all records in a matter of minutes.

A major consideration for using computers is the lack of manpower. In

our case, if we relied upon our existing personnel to process our records by the old desk calculating methods, we would not be able to keep up with incoming data. The computers free our personnel from the drudgery of punching a calculator hours on end doing routine, endless sums. The present number of your stream-gaging stations (13) alone is cause for strong consideration of ADP methods. In addition, you could no doubt use ADP advantageously for precipitation, soil moisture, and other data.

When ADP programs were first being developed, a lot of time was spent in selecting the input and output parameters and in getting the programs to work. Because of the numerous research units that now have running programs, you can probably find a program ready made for your use. If you have to modify these to fit your special needs, the changes could likely be made in a minimum of time--certainly not the time required to start from scratch. We would be glad to send you copies of our program for streamflow and precipitation. You may want to contact some other U.S. federal agencies that are using ADP methods:

U. S. Forest Service, Pacific Southwest Forest and Range Experiment Station, Berkeley, California, and Glendora, California

U. S. Forest Service, Southeastern Forest Experiment Station, Coweeta Hydrologic Laboratory, Franklin, N.C.

Agricultural Research Service, Sleeper River Watershed, Danville, Vermont

We agree with Dr. Lull that ADP methods can become a crutch for thinking but we strongly feel they can provide time for thinking! We wouldn't consider doing hundreds of problems of multiplication and division by longhand with pencil and paper if a desk calculator were handy. Likewise, why should we waste time doing thousands of problems on a desk calculator if a computer is handy.

If you are compiling data now for analysis much like our unit (and I assume you are) and anticipate using this and other data in the future comparing relationships between various environmental factors, I recommend ADP methods.

Regarding the Fischer-Porter ADR, we tried it for several years and concluded for our work a pen trace was much preferred over a punched

tape. Streamflow in our watersheds is very sensitive to climatic events. These and other idiosyncrasies of each watershed call for a visual chart trace that allows ready detection. The punched tape does not permit such inspection. We use Leopold-Stevens A-35 water level recorders with negator spring drives for measuring streamflow in V-notch weirs. Where there is need for assurance of record back-up, Belfort FW-1 is used. These are also used in our San Dimas flumes.

If we can help you further, please let us know.

Sincerely yours,

Robert S. Pierce
Project Leader

COPY

Southeastern Forest Experiment Station
Coweeta Hydrologic Laboratory
Franklin, North Carolina

April 12, 1967

Mr. Teja Singh, Research Scientist
Forestry Branch
132 - 9th Avenue, S.W.
Calgary, Alberta

Dear Mr. Singh:

I am responding to a copy of your letter sent to Howard Lull, dated March 21, 1967.

As you mentioned, some time has passed since the 1962 Watershed Management Research Conference at Laconia. The procedures and processes that were at that time being instituted at Coweeta are nearing completion. I am enclosing a copy of a paper by A. R. Hibbert and G. B. Cunningham which outlines the data processing system we use in handling streamflow data from strip charts and ADR tapes. A second paper by J. D. Hewlett and A. R. Hibbert illustrates one example of how this data can be used. With the data in its summarized form, we are able to extract much more information than was previously possible and are turning up unexpected treatment effects which bear importantly on functioning of forested watersheds.

In processing data, we use the semiautomatic chart reader for charts and the ADR tape-to-card translator for tapes. Table 5, page 735, of the Hibbert-Cunningham paper presents the best cost estimate we have on processing these two types of records where translation was contracted out. The cost of processing the ADR records was considerably higher than the cost of processing charts because of high translation cost. By owning our own translator, we reduced translation costs by about 50 percent, and now cost of processing the two types of records are approximately equal.

In response to your first question, we are quite pleased with the operation of the ADR water level recorders. They are extremely accurate, reliable, and are ideal for our purposes. Whether or not these recorders should be replaced depends upon a number of factors including the condition of your existing instruments and the type of automatic data processing equipment and procedures anticipated in the future. There is an advantage to having a single type recorder for rain gages, wells, and

water level recorders since this simplifies data processing. But, as mentioned previously, the use of the ADR does not necessarily mean that the cost of processing the data will be reduced. It might be pointed out that chart records (thermograph, etc.) would still have to be reduced manually or on a chart reader.

The answer to your second question depends to a large extent upon the use to be made of the data. For research purposes, we do not believe that past methods of compiling streamflow data from watersheds are adequate. Figures 8, 9, 10, and 11 in the Hibbert-Cunningham paper illustrate the amount of useful information we are obtaining for each gaged watershed. You may be interested in comparing this to the published output by U. S. Geological Survey in water supply papers. It is doubtful that this amount of data could ever be obtained by hand-picking methods, and then only at a substantially higher cost than we are now paying.

At Coweeta we found that it was absolutley essential for us to go to computers to handle our backlog of streamflow data and to keep the current workload of 15 water years per year up to date (we also process about 20 water years of data for others giving the entire output shown above for about $150/water year). We are near completion of programs for computerizing rainfall intensity data for 12 recording rain gages in operation plus approximately 400 years of rain gage data collected in the past. Since you have nearly this workload (either in operation or in progress), I would strongly consider going to computers. If you must pay for programming costs, purchase a chart reader, an ADR tape-to-card translator, and ADR recorders, the initial investment would be quite large. It might be possible to contract the extraction of data from charts and tape translation with some data processing center, but it would probably be cheaper in the long run to own your own equipment.

In response to your fourth question, we have already put our backlog of streamflow data (almost 500 years) on punched cards and are in the process of doing the same for our rainfall data. There are real advantages in having all the data in the same format and all the data on one gage or instrument summarized in one place. To date, we have only worked with streamflow and rain gage data, but using the chart reader, data from hygrothermographs, thermographs, recording radiometers, and other types of recording instruments can be extracted in a similar manner. I am not sure it would pay to develop computer programs for some of the meteorological data you are collecting (soil temperature, soil moisture, wind movement, maximum and minimum temperatures, and evaporation). It might be simpler and cheaper to do this by hand unless these data are recorded on punched tapes using the ADR logger or similar type equipment.

The data processing system which has been developed here at Coweeta is the best procedure in existence for handling streamflow data for research

purposes. We are getting more information at a lower cost than any other hydrologic station in the Forest Service. Since you are wrestling with the problem of data processing, you might find it advantageous to visit the Hydrograph Laboratory at Beltsville, Maryland, the U. S. Geological Survey Data Processing Organization (I do not know where they are located), hydrology field stations in the Northeast, and Coweeta to ascertain just how each is handling their data processing load and to compare the amount of useful information each is getting from their analyses. Then, you would be in a much better position to decide whether or not to computerize your hydrometeorological data. We welcome a visit and will be happy to help in any way we can.

Sincerely yours,

James E. Douglass
Project Leader

COPY

THE UNIVERSITY OF GEORGIA
School of Forestry
Athens, Georgia

April 3, 1967

Dear Howard:

Thanks for the letter to Mr. Singh--I agree with much of what you say and there is no question that a lot of current activities with the computer falls under the heading of "creative play period." However, I am afraid that we must face the fact; eventually it all is going to be computerized whether it initially makes sense or not. As McLuhan says, "The medium is the message!"

May 10, 1967

I went back and reviewed Singh's letter after your note the other day and remembered that I did not write to him at the time I sent you the other note. My reasons for not writing him were about as follows:

I did not feel that Mr. Singh's questions could be answered as he posed them. Methods of data logging summarization and computation cannot be evaluated in the absence of a careful analysis of the research objectives, which I could not find in his letter. He asks is this or that method justified, or adequate? But adequate for what? If they wish to determine a 0.1 inch per month change in water yield due to some treatment, then the most reliable and accurate instrumentation available is justified. Or if they wish to verify the application of Penman's vapour-energy transfer method to Calgary conditions, then massive amounts of data may be needed. If however, the effect of logging on sediment yield or channel stability is the main thing they are interested in, then very little instrumentation is justified. What line of thinking led them to selection of the variables they are now collecting?

If the truth be known, I suspect the reasoning went something like this: New concepts and other good things have come out of the Coweeta-Fraser-Fernow-San Dimas-type set ups. Therefore Canada ought to have one, if for no other reason than training, concept development and to make the public aware of watershed problems. Here again the medium is the message, and very likely the medium should avail itself of the latest scientific hardware and software to be really effective. Sooner or later those foolhardy enough to get themselves all tangled up in mechanized data collection and reduction are going to be forced to justify its use. Oddly enough you can develop some pretty clever lads that way!

Or so the argument might run. Personally I prefer the tight objective, the lucid hypothesis, the experiment, or the simple mechanical job to be done, and then the selection of methods. Even under this criterion

we turned to automation and the computer while I was at Coweeta to do certain things which otherwise just didn't seem possible--always of course with an eye on cost, but not on rigid cost-benefit analysis.

So in short I felt like saying to Mr. Singh, "Jump in. The water's fine!" But I didn't know how to answer his questions.

Yes, you may use any or all of this if you wish.

Best regards,

/s/ John
John D. Hewlett